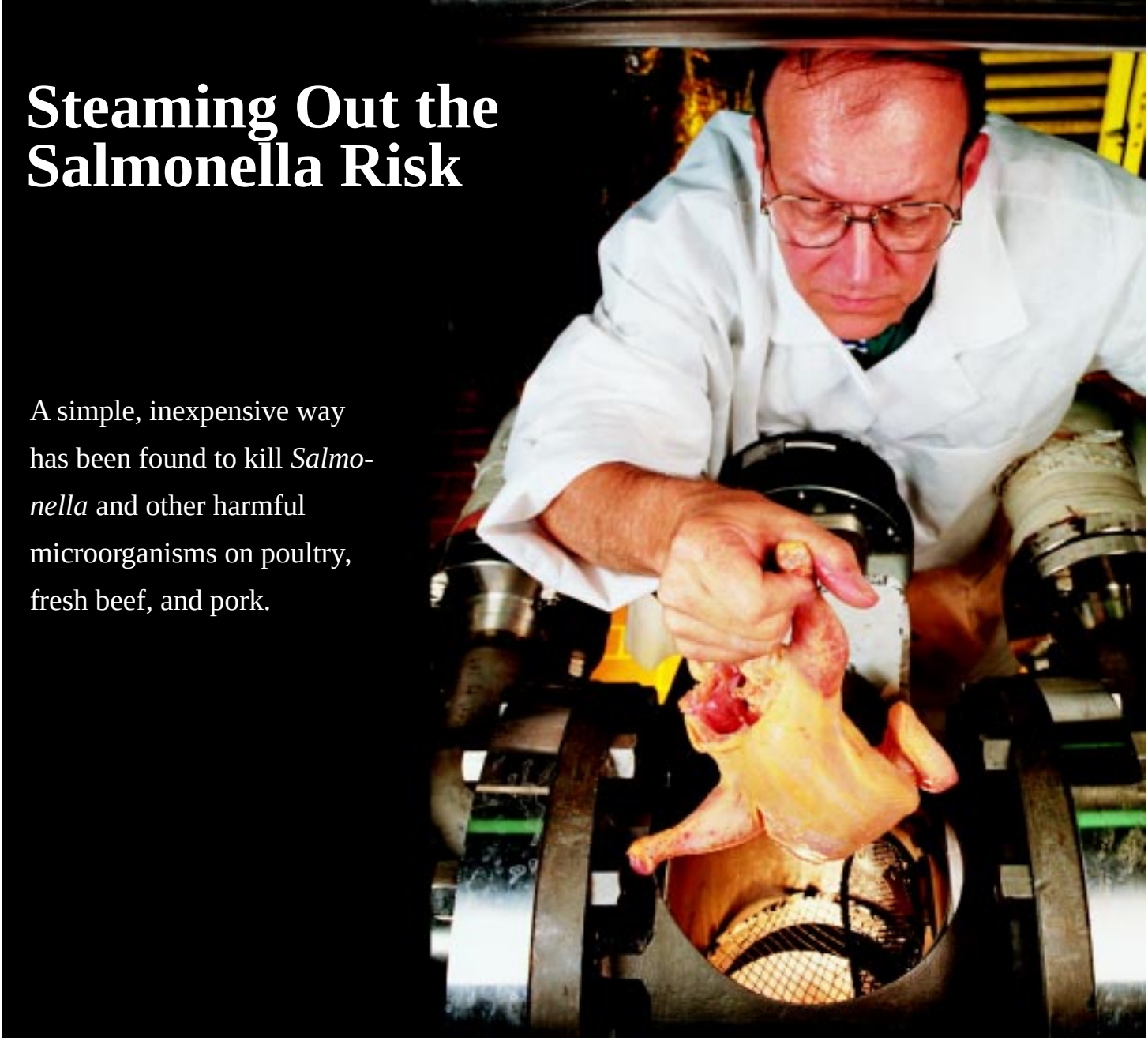
Steaming Out the Salmonella Risk

A simple, inexpensive way has been found to kill *Salmonella* and other harmful microorganisms on poultry, fresh beef, and pork.



Chemical engineer Rich Radewonuk inserts a Cornish hen into an experimental chamber where a brief burst of 290°F steam will kill 99.99 percent of surface microorganisms.

KEITH WELLER (K7739-11)

The cool September breeze ruffles the napkins on the Labor Day picnic table that is groaning under the weight of hot, barbecued chicken, fresh potato salad, and steaming baked beans.

Do the flulike symptoms of Salmonella foodborne illness await these picnic goers? Probably not.

But there would be even less chance if a new processing technique for poultry and raw meat designed by Agricultural Research Service chemical engineer Arthur I. Morgan gains widespread use.

Morgan has discovered a simple, relatively inexpensive way to kill *Salmonella* and other harmful microorganisms on poultry, fresh beef, and pork—good news for food processors and consumers alike.

At the ARS Eastern Regional Research Center (ERRC) in Wyndmoor, Pennsylvania, Morgan and colleagues have designed, built, tested, and patented a device that kills bacteria on the surface of raw meat. Without cooking the meat—and in just 25 milliseconds—this device kills 99.99 percent of bacteria by heating the meat surface quickly with steam and cooling it in a vacuum. Their prototype machine could be used easily online in processing plants.

"Harmful microorganisms usually dwell only on the surface of intact meat," Morgan explains. "This is true of enterobacteria, like *Salmonella*, which originate in a living animal's gastrointestinal tract."

This means, he says, that before slaughter there are no toxic bacteria under an animal's skin. However, since the gastrointestinal tract (GI) is removed during processing, in some

cases bacteria may be spread from the contents of the GI tract to the meat surface.

Contamination may also result from contact with workers' hands, with slaughtering equipment, or with chilled-water treatment baths that carcasses are immersed in. One contaminated bird raises the potential of spread to other carcasses.

"Industry has a hard time removing surface contaminants from meat because microorganisms hang on tenaciously. Many escape hot-water washes or sprays containing bactericide and surfactants," says Morgan.

"This is true even when exposure time and bactericide content are more than enough to sterilize a smooth surface. We've seen contaminants remain on meat even after we've used organic acid solutions and trisodium phosphate."

One of the reasons that existing methods aren't very effective in killing the harmful microorganisms is because of the liquid nature of water. "Water can't reach all the contaminated surfaces. Feather, hair, or scale follicles are large enough to hide bacteria, but too small to admit a liquid wash or spray," Morgan says. "An impossibly high water pressure would be needed to overcome the capillary pressure in a pore just large enough to house a bacterium."

This makes it difficult for liquid washes to totally eliminate contaminants on meat surfaces. And the meatpacking industry is limited in using heat because meat must keep its raw appearance or consumers won't buy it.

Morgan came up with the idea of surrounding the carcass with vacuum, then applying a short burst of steam, and finally cooling the surface with the vacuum to kill microbes without cooking the meat.

"We knew that bacteria can be destroyed by disrupting their metabolism, which is exactly what the steam does," Morgan says. "Heat conduction throughout a piece of meat is much slower than surface heating by steam condensation. We figured that if the heating rates of meat and microorganisms were equal, the bacteria would die before the meat cooked. Therefore, we knew that it's possible to surface pasteurize meat without cooking it."

KEITH WELLER (K7740-1)

Mechanical engineers Arthur Morgan (left) and Neil Goldberg prepare to record data from a test run.

The equipment that Morgan uses to prove his theory consists of an 8-inch, stainless steel ball valve with an 8- by 11-inch treatment chamber that will easily hold a chicken dropped in with its legs first. Two computer-controlled gas valves admit either steam or vacuum into the treatment chamber. Steam is generated in one 50-gallon tank, and another serves as a vacuum receiver. Both tanks are connected to the treatment chamber by short lengths of 3-inch tubing.

In 1 second, this machine takes the chicken through a vacuum to withdraw all air, flushes it with steam, treats it with a burst of steam heated to 290°F to kill harmful bacteria, and finally vacuum-cools it—all without cooking the surface.

"Vacuum treatment before steam heating removes 98 percent of the air around the meat, and flushing with low-temperature, no-air steam eliminates the rest. We use low-temperature steam in this case so the meat won't be warmed prematurely," Morgan says. "Removing the air before treating with steam actually makes the treatment more effective, since the air would otherwise slow down the rate at which the steam heats the meat surface."

"A commercial version of one of our machines could treat 4,000 birds an hour. This means that if we built multiple chambers for birds, capacities would be in multiples of 4,000 for each machine," says Morgan. "Our total cycle time indicates that one machine can serve an entire broiler processing line—after the chill tank and before the clean cut-up line."

"We got similar results with beef and pork. However, we think that more pathogens can be killed on beef and pork by using higher temperatures for shorter times and still not cook the meat.

"Future work focuses on adapting the process to industry. This equipment could be added at the slaughterhouse without increasing costs more than a cent per pound. We're looking for a company that might like to license our device, which is patented in the United States and Canada."—By **Doris Stanley**, ARS.

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